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DECISIONAL DIFFERENCES AMONG INDIVIDUALS: A SIGNAL DETECTION THEORY APPROACH

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Naval Aerospace Medical Research Laboratory
Pensacola, Florida

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NAMRL - 1185

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Approved for public release; distribution unlimited.

Unclassified
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Naval Aerospace Medical Research Laboratory, Naval Aerospace Medical Institute, Naval Aerospace & Regional Medical Center, Pensacola, Florida 32512	2a. REPORT SECURITY CLASSIFICATION: Unclassified
	2b. GROUP

3. REPORT TITLE

DECISIONAL DIFFERENCES AMONG INDIVIDUALS: A SIGNAL DETECTION THEORY APPROACH

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

5. AUTHOR(S) (First name, middle initial, last name)

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LT Jack B. Shelnutt, MSC, USNR

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
18 June 1973	~~20~~ 28	78

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO. MF51.524.004.5002BX5G	NAMRL-1185
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) .16
d.	

10. DISTRIBUTION STATEMENT

Approved for public release; distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

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On the basis of the R-T literature review, a number of serious weaknesses and difficulties in existing R-T measures were enumerated. Because of these problems, an attempt was made to determine an alternative measure which stressed the decisional aspects of the R-T situation. This involved the application of the Signal Detection Theory framework to a psychophysical task of changing signal probabilities. The validity of this approach for determining decisional differences among individuals was investigated in an auditory detection task of very limited length. The results in general were favorable to this alternative approach to measuring meaningful individual differences along a statistical decision dimension.

DD FORM 1 NOV 65 1473 (PAGE 1)

S/N 0101-807-6801

Unclassified
Security Classification

i

Unclassified
Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Risk-taking						
Decision-making						
Signal Detection Theory						
Selection						

DD FORM 1 NOV 65 1473 (BACK)
(PAGE 2)

Unclassified
Security Classification

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SUMMARY PAGE

THE PROBLEM

The applicability of current theory and measures of risk-taking (R-T) to the understanding and selection of military aviators was investigated. The project consisted of three interrelated sections: (1) an extensive review and critique of the literature in R-T, (2) the development of an alternate measure emphasizing the decisional aspects of R-T, and (3) preliminary findings of a brief study employing the proposed Signal Detection Theory measure.

FINDINGS

On the basis of the R-T literature review, a number of serious weaknesses and difficulties in existing R-T measures were enumerated. Because of these problems, an attempt was made to determine an alternative measure which stressed the decisional aspects of the R-T situation. This involved the application of the Signal Detection Theory framework to a psychophysical task of changing signal probabilities. The validity of this approach for determining decisional differences among individuals was investigated in an auditory detection task of very limited length. The results in general were favorable to this alternative approach to measuring meaningful individual differences along a statistical decision dimension.

ACKNOWLEDGEMENT

The authors wish to express their appreciation to LCDR Richard S. Gibson, MSC, USN, and his staff for their indispensable aid in the computerized aspects of this project.

INTRODUCTION

Flying military aircraft is a hazardous business. Bond (6) suggested that military aircrewmen differ from the general population with respect to their willingness to be employed in such a dangerous occupation because of a basic personality difference. More recent studies have also explored this apparent propensity for risk-taking (R-T) behavior in military pilots (16, 18, 49, 50, 52). These studies, which have employed a predominantly psychiatiric approach (i.e., personality inventories, background questionnaires, and clinical interviews), have reported significant differences between military aviators and the general population along the R-T dimension. From these reports, it appears that this attitude toward R-T shared by military aviators may reflect a basic personality characteristic or "trait" on which they differ from the population in general.

Granting this characteristic R-T difference between military pilots in general and the population at large, the project to be described in this report was concerned with the feasibility of developing an objective, behaviorally determined measure which would reliably differentiate such individuals on the basis of their predisposition for R-T. If such a measure could be determined, it would not only contribute to a greater understanding of the aviation community in general, but could also be of some practical value in the selection of future aviators.

The research project described in this report is composed of three parts (1) a survey of current R-T theory and research which attempts to present the status of the area and evaluate its applicability to the aviation setting; (2) the theoretical development of an alternate measure which avoids the most common methodological pitfalls of current R-T indices; and (3) an initial empirical attempt to determine the feasibility of the newly proposed measure which employs the Signal Detection Theory model and statistical framework.

I. RISK-TAKING: A REVIEW OF THEORY AND METHODS

From its early origins in economic theory, and its subsequent adoption in the early 1950s by psychology in theories of decision-making (12, 13), R-T has branched into many and diverse areas of the adopting science. Statistical decision theorists, as well as personality and social theorists, have investigated R-T behavior from their particular viewpoints. However, a resultant lack of clarity in the R-T literature has also been recognized by a number of researchers (32, 40, 41, 42, 57, 58, 60, 69). Several reasons for this confused state have been proposed.

First, the term "risk-taking" itself is extremely vague, and its current usage encompasses a multitude of behaviors. Although, as Slovic (57) has

stated, there is "little concern in the literature with problems inherent in defining and assessing this presumably general personality characteristic," there are, nevertheless, many supposed R-T measures employed in current research. These measures embrace such disparate behaviors as responding to simple personality questionnaires (68), betting preferences on dice games and other games of chance (40, 41, 42, 48, 53, 59, 62), skillgame play (3, 10, 20, 36, 41, 42, 64), choosing alternatives in hypothetical real-world situations, performance on games of simulated international conflict (25, 26), and many others. This wide range of behaviors itself gives some indication of the multidimensionality of the R-T concept as it is currently employed. Furthermore, when performance on several of these hypothetical R-T tasks has been compared, little convergent validity has appeared (1, 57, 58, 59).

Second, there are a multitude of factors, internal (personality and motivational) and external (situational), which have been shown to be related to one or more of the R-T measures described above. Commonly, a researcher has selected a single such R-T measure and has attempted to relate to it some organismic, personality, or situational variable(s) such as sex (71), age (72), achievement motivation (2, 20), manifest anxiety (31, 41), level of stress (35), type of opponent (34), group vs individual settings (26, 32), length of decision time (61), etc. Although only a single R-T measure, such as betting on dice throws, may have been investigated in a particular study, the findings have tended to be reported under the general summary term "risk-taking." The end result of this lack of discrimination between methods or settings has generally been claimers, disclaimers, confusion, and contradictions throughout the R-T literature.

It appears, then, that the present state of knowledge concerning R-T strongly supports Slovic's repeated contention (52, 58, 59) that such behavior is not as "conceptually unitary as many psychologists would like it to be." This failure to demonstrate trans-situational generality for individual differences in R-T performance has been replicated by many other researchers (7, 17, 24, 42, 73). Hence, it appears that unless there is a restraint in the use of such a broadly inclusive term as "risk-taking" for this myriad of behaviors, the confusion of claims concerning the many investigated variables within the R-T realm may never be reduced.

II. DETERMINATION OF AN ALTERNATE DECISIONAL MEASURE

A. Theoretical and Methodological Considerations:

Given the present state of the R-T realm, there appears to be little value in adding yet another study to the area. However, the current Zeitgeist continues to foster the notion, both within and beyond the aviation

community, of the "daredevil aviator." Since inherent within the R-T concept is the core element of a decision-making task (under risk), perhaps the aviator's characteristic behavior could best be approached from this alternate route. In other words, it may be possible to demonstrate a difference between the aviation community and the general population in basic decision-making behavior. Such a restatement of the R-T question shifts the emphasis away from the risk element and focuses more upon the decisional aspects of a situation. The factor of "risk" is relegated to a parametric position within the broader decisional framework. Consequently, the present paper examines individual differences exhibited on a decision-amking task under various conditions. Such an approach to the understanding of the hypothesized "risky behavior" of aviators may avoid many of the serious problems encountered within the R-T area.

As the result of the numerous problems described in the previous section, it was concluded that the determination of an appropriate decisional measure for the aviation setting should be made on strong methodological as well as theoretical grounds. The selected measure should accurately reflect the decisional or judgmental aspects of R-T while avoiding some of the common pitfalls of existing tests or scales.

The methodological considerations involved in selection of this decisional measure were derived in large part from well documented problems in the R-T literature. For example, such researchers as Kogan and Wallach (32) and Slovic (58) have stated that the often highly artificial or hypothetical atmosphere existing in much of the R-T research may have resulted in capricious, situation-specific responses rather than true indicants of any underlying behavioral trait related to R-T. Another common but serious problem in such research has been the ease with which an individual might "fake" a risky or a conservative response on a selected R-T measure in order to satisfy what he thinks the experimenter might want or even what he thinks he "ought" to do. How adequately this reflects his behavior in a "real-world" situation is unknown. There has also been the problem of the "risk" itself. Rarely do the experiments actually challenge the individual with true risk, but rather tend to rely on small monetary losses or gains or simply hypothetical threats or rewards in make-believe situations. How adequately the individual's behavior in such settings reflect his actual propensity for R-T behavior is also unknown. It was believed that a basic decision-making task was less likely to face these common R-T problems to the same extent.

In addition to the restrictive conditions mentioned above, several additional considerations in this search for a decision measure were taken into account. It was desired that the measure be as automated as possible and also be capable of administration within an experimental period of reasonable length. Such factors would increase the measure's degree of applicability by augmenting

the level of standardization as well as by enhancing its practical utility by adding to the total number of Ss who could be run within a given time frame. On a more theoretical note, previous researchers (16, 50) had characterized the military aviator not as a foolishly risky individual, but rather as a person willing to take the risk if the situational odds so dictated. Therefore, it was also desired that the decisional task selected must somehow reflect this situational component of R-T, in order to adequately simulate the variable decisional aspects of genuine aviation-related R-T behavior.

B. Signal Detection Theory Approach

A further advantage of shifting the emphasis on R-T to the decisional aspects of the setting in which such behavior occurs rested in the possibility of applying new approaches to the analysis of such performance. Statistical decision theory as formalized in Signal Detection Theory (SDT) represented just such an approach (21, 65). An analysis of an individual's behavior on a classical psychophysical task according to the tenets of SDT results in a measure of the individual's response criterion, Beta, as well as the more common measure of his sensitivity. Within SDT, this Beta value not only reflects the level or degree of "response conservativeness" exhibited by the individual under any particular stimulus conditions (e.g., a priori probabilities of signal presentation, pay-off matrix for "hits" and "false alarms"), but also allows a relative comparison of the individual's degree of response conservativeness across situations of various stimulus conditions. This comparison makes it possible to observe any change in the individual's criterion as the signal probabilities or other parameters are experimentally manipulated. Theoretically, it reflects the person's ability to "match" the changing signal conditions with an appropriate shift in his level of response criterion (conservativeness). In the present context, this factor of changing situational parameters was seen as important in the attempt to assess the degree of flexibility of the individual's response criterion level as relevant conditions of the setting are altered. It was hypothesized that this factor may to some extent involve the situation specificity of the aviator's R-T behavior referred to previously.

In the present study individual differences in performance on an auditory detection task under varying conditions of signal probability were investigated within a Signal Detection Theory framework, with primary emphasis upon the individual's Beta values across conditions. Beyond the value of the SDT approach already enumerated, an auditory detection setting also appeared to hold the advantage over other possible decisional measures in that it was believed less likely to reveal to the individual its actual nature and would thus be less "fakable." Described to the individual as an "auditory task," it was thought to appear less artificial in S's eyes ("hearing tests" are usually conducted in laboratories) and therefore would reduce the capriciousness or bias of

his responses. This criticism of artificiality or fakability with regard to the usual R-T indices has been described above. However, the reliability and consistency of the individual's performance as obtained by SDT analysis of a psychophysical task has been demonstrated both over trials (30, 64) and across modalities (23, 46).

A further advantage of the basic detection paradigm and SDT form of analysis for the determination of individual differences in decisional characteristics was the large body of previous SDT research into the many parameters of the experimental detection setting. Furthermore, the SDT approach to the investigation of individual differences, although generally on the sensitivity dimension, has been employed by other researchers. The use of SDT as an experimental means of investigating behavioral differences is by no means original with this study. Price (47) reviewed a number of studies in personality and perception which successfully utilized SDT and suggested other areas for future investigation within the SDT framework. Treisman and Watts (70) reported a relationship between "rigidity," as measures by the Luchins' water jar test (39), and the subject's response criterion on an auditory discrimination task. De Fazio and Moroney (11) attempted to relate Witkin's concept of field dependency-independency (76, 72) to performance on an auditory signal detection task. Tong and Ground (67) demonstrated the differential effect upon response criterion of the type of instruction for low rigidity vs high rigidity subjects. A large number of researchers (5, 8, 37, 75) have attempted to analyze performance on vigilance or monitoring tasks within the SDT conceptual framework. Lockhart and Murdock (38) described the application of SDT to the analysis of memory data, while Siegel and his associates (55, 56) obtained SDT measures from S's performance on true-false tests in an academic setting.

Of more direct importance for the present study was the article by Poortinga (46) in which he proposed the use of the SDT paradigm and form of analysis as a method for determining reliable R-T differences between individuals. He believed these differences to be observable in the numbers of "more confident" rated responses reported by each individual on a detection task. Poortinga was able to report reliable individual differences in the number of such responses across modalities (visual and auditory detection) and hypothesized this consistency in the individual's detection behavior to result from underlying R-T related differences in personality among his Ss.

The present study differed markedly from Poortinga's in that the major experimental condition of changing signal probabilities were introduced. While Poortinga was primarily concerned with demonstrating the consistency of the individual's relative frequency of "more confident" responses on psychophysical tasks, which he hypothesized to be an indicant of R-T, the present research

focused upon the individual's ability to change his criterion or degree of "conservativeness" as the situational conditions in which he formulated his psychophysical decision were altered. As outlined previously, it was hypothesized that the analysis of such decisional behavior assessed that situation component of R-T decision-making referred to by prior investigators (50).

In summary, the present study proposed that the same type of decisional aspects of genuine R-T behavior are reflected in the pattern of responses demonstrated on an auditory detection task. As the conditions of a priori signal probability are systematically varied within the SDT framework, it is theoretically possible to determine concurrent shifts in the individual's decision criterion or conservativeness of responding. If this contention proves true, individual differences on the detection task might then serve as practical indicants of differences in decisional strategies among individuals. Although the psychophysical detection task of the present study bore little face validity for simulation of the physical threat and/or hedonistic thrill of actual flying, it hypothetically reflected some degree of the same judgemental aspects of behavior. In other words, it may have served to evidence a characteristic orientation within the individual's behavioral repertory which separates him from others along a decisional dimension of human behavior.

C. Initial Validation of the SDT Approach to Individual Differences

Before a meaningful discussion of the theoretical and practical value of the individual criterion measures obtained on some detection task was believed possible, it was necessary to establish the validity of such measures as valid indices of the individual's "conservativeness" in the setting selected. The remainder of this report deals with the experimental attempts to demonstrate the meaningfulness of these derived statistics in the particular experimental design employed. This initial validation of the applicability of SDT analysis was deemed necessary because of certain elements in the present design which differed from most other SDT investigations of a similar nature (65, 66). The great majority of studies in the literature employing SDT have run each subject for at least hundreds and usually thousands of trials over weeks or even months, with the result that the measures obtained reflected the behavior of well-practiced, experimentally-experienced individuals. Although a relationship between such an extensive measure and existing academic and/or psychological criteria in naval aviation training would be of theoretical interest, it would have limited practical applicability given the restricted availability of flight students within the tightness of the training schedule. Therefore, the present study attempted to obtain meaningful criterion measures (Beta) under three different conditions of a priori signal probability of only 60 trials each. An overall (across-subjects) shift in Beta values from one signal probability condition to

another in a manner consistent with SDT would provide theoretical support for the general design of the present experiment as well as for the practical effectiveness of the changing probability conditions as criterion-shifting parameters in the selected decisional setting.

Following the basic concepts of SDT (65), systematic increases in signal probability were expected to result in a downward shift in the individual's degree of "conservativeness" (Beta) from Condition A (10-stimuli-50 blanks) to Condition B (30-30) to Condition C (50-10). The parameter of signal probability, like payoffs and costs for "hits" and "false positives" in other studies, has been demonstrated to be an effective variable in determining the level of the observer's response criterion (54, 63, 65). These previous studies, however, have used hundreds or thousands of trials for determining such a measure. In fact, it has been stated that SDT is only fully applicable in situations in which the time element is not highly critical (21), since only with a large number of trials can the assumptions underlying the sensitivity measure d' and the criterion measure Beta with SDT be considered adequately met. A major concern of this initial report was to determine the utility of SDT analysis for a psychophysical task of drastically reduced length. Whether such an approach is tenable for the investigation of psychophysical phenomena was not of primary interest. Rather, the emphasis was upon the feasibility of the shortened SDT approach as a determiner of meaningful and reliable individual differences along a decisional dimension.

METHOD

Subjects. The 42 Ss employed in the present research were Aviation Officer Candidates (AOCs) or Naval Flight Officer Candidates (NFOCs) assigned to the Naval Aviation Schools Command, Naval Air Station, Pensacola, Florida. The auditory detection task to be described below was added to the battery of physical and psychological tests routinely administered to incoming flight students.

Apparatus. A Bell-Tone Model 10C sound generator was employed to present both the auditory signals and the constant random noise background to the Ss over dual Grason-Stadler headsets (Model TDH39300Z). The intensity of the random noise was maintained constant for all Ss and over all trials throughout the entire experiment. The intensity and frequency of the auditory signals employed could be controlled by E, although in the present experiment the signal frequency of 1000 HZ was held constant over all trials. The equipment design was such that signal presentation could be controlled manually by E or in real time by interfacing with a UNIVAC 418 computer.

Procedure. Each S was tested individually in a single experimental session lasting approximately 45 minutes. All testing was performed in a small testing cubicle located in a semi-dark, quiet room.

Part I. In Part I each S was instructed that the general purpose of the experiment was to determine the ability of individuals to detect auditory signals presented over a constant noise background similar to radio static. He was informed that his task was simply to respond when he believed he heard the brief auditory tone over the "static noise" which was presented continuously through the headsets.

S was instructed that, at the beginning of each trial in Part I, the green light located in the control box in front of him was to be manually turned on by E and remain on for 1 second. The offset of this warning light was to coincide with the presentation of a 2-sec. auditory signal of 1000 Hz. If the S detected this signal, he was instructed to depress the warning light which activated a light in E's adjoining cubicle. In this portion of the session, E manually recorded S's responses.

The intensity of the auditory tones on these trials in Part I was controlled by E. These trials were run according to the "method of limits" to determine a classical "threshold" value for each S. This involved five ascending intensity trials alternating with five descending intensity trials. These 10 trials lasted approximately 15 minutes and were followed by a short rest period of 2-3 minutes before the second portion of the experiment was begun. During this period, E calculated S's "threshold" value from the initial trials (78).

Part II. Part II of the session involved three sets of 60 trials each, which differed from one another on the basis of the actual number of auditory signals present within the 60 trials. Condition A contained 10 signal trials and 50 blank trials; Condition B, 30 signals and 30 blanks; and Condition C, 50 signals and 10 blanks. The order in which S received these three conditions was randomly determined (within a counterbalanced design), as was the actual sequence of signal and blank trials within each of the three conditions. For each S the intensity of the auditory signals was maintained constant throughout all three conditions of Part II at that intensity level determined as S's "threshold" in Part I. Prior to the start of the first condition and during the 2-minute rest periods before each of the next two conditions, S was allowed to remove the headsets while he read a detailed description of the 60 trials to follow. In this description he was informed as to the exact number of signal and blank trials which would be contained in the total 60 trials of the following condition. A copy of the instructions read by S prior to Condition A (10 signals-50 blanks) is contained in Appendix A. The instructions for Conditions B and C were very similar, with only the numerical values changed to correspond to the respective signal condition.

The temporal arrangement of trials within conditions consisted of a 3-second warning light, the onset of which was followed one second later by the 1000 Hz signal (if that trial contained a signal). The auditory signal and warning light terminated simultaneously. A 5-second interval was maintained between the termination of one trial and the onset of the next. (S was carefully instructed as to this arrangement of the warning light and test stimulus prior to each condition).

Part II also differed from Part I in that all conditions, all trials within conditions, and all intertrial and intercondition intervals were controlled by the online computer. This effectively automated Part II and ensured equivalence of design across Ss. The computer also recorded all Ss' responses during the total 180 trials of the three conditions as well as the latencies of all the Ss' responses throughout the experimental session.

COMPUTATION OF BETA AND d'

Beta.

Beta values were calculated by the procedure described by Welford (74) and more recently by Hochhaus (28). This involves the utilization of a prepared table to obtain the normal curve ordinate values corresponding to the proportion of the S's "false negatives" (pNOsn) and the proportion of his "false positives" (pYESn) during the 60 trials. The Beta for each S per Condition could then be computed directly from the general formula:

$$\text{Beta} = \frac{\text{Ordinate for pNOsn}}{\text{Ordinate for pYESn}}$$

The Beta values obtained in this way were then transformed into loge (Beta + 1) values. Such a transformation of the raw Beta socres has become common practice in much SDT research, due to the skewness which results from these scores having a lower limit of zero but no necessary upper limit. By adding the constant of 1 to the raw Beta scores before taking the logarithm, all scores were made positive.

d'.

The other most commonly reported measure within SDT, d', was also investigated in the present study, although the measure was not of primary interest. This parameter d' has been hypothesized to reflect S's sensitivity in the detection setting and, unlike Beta, is hypothetically unaffected by the previously described criterion-shifting treatments (21, 63). These d's measures were also calculated from the procedure described by Welford (74) and Hochhaus (28). The normal deviates (ND) for the proportion of false negative (pNOsn) and false positives (pYESn) were again read from a prepared table and then substituted in the formula:

$$d' = \text{ND for pNOsn} + \text{ND for pYESn}.$$

During the study a complication arose concerning the calculation of d' and Beta, resulting from the basic procedural design employed. Approximately one-third of the Ss responded on one or more trials during the one-second period between the onset of the warning light and the onset of the auditory signal. Such responses were very infrequent, comprising less than 5 per cent of the total responses, and were therefore not viewed as a serious problem. However, because in this preliminary investigaton the computer was programmed to accept and record only S's first response on any given trial, there was some concern over how to treat these trials which contained early responses. Most research within SDT does not have this problem, due to the highly practiced Ss employed and to the use of a specified response interval after the signal's presentation during which S gives his response for the preceding stimulus interval. The present study intentionally avoided both these controls, because of the desire for a short, practical measure, and because of the current interest in S's response latency and its relationship to the criterion scores reported by previous researchers (15).

To deal with this problem it was arbitrarily decided that, if the trial did not contain any auditory signal, this early response was recorded as a "false positive" (FP), since even if S were to respond later in the trial, he would still be making an FP. However, if the trial actually did contain the auditory signal after S's preliminary response, it was unknown whether S responded a second time in that same trial or not. Therefore, it was decided to assign either "false negatives" (FN) or "correct hits" (CH) to these trials, depending upon which S was more likely to have made as exhibited by his behavior on the majority of the other trials in the condition. In future work, all the S's responses per trial will be recorded and the possible significance of these early responses will be investigated.

ANALYSIS/RESULTS

Figure 1 presents graphically the relationship between the mean transformed Beta values across all Ss for the three signal probability conditions. As predicted within an SDT framework, a decrease in criterion measures from the low signal frequency condition to the high signal frequency condition is evident. The statistical significance of this trend is reflected in the ANOVA summary table (Table I) by the highly significant Condition effect. Further analysis of this significant Condition effect indicated that all three Conditions were significantly different from one another $t_{A-B} = 3.179$, $df = 41$, $p < .01$; $t_{A-C} = 4.435$, $df = 41$, $p < .001$; $t_{B-C} = 2.277$, $df = 41$, $p < .05$). The other main effect of Order was insignificant as was the Condition X Order interaction (see Table I).

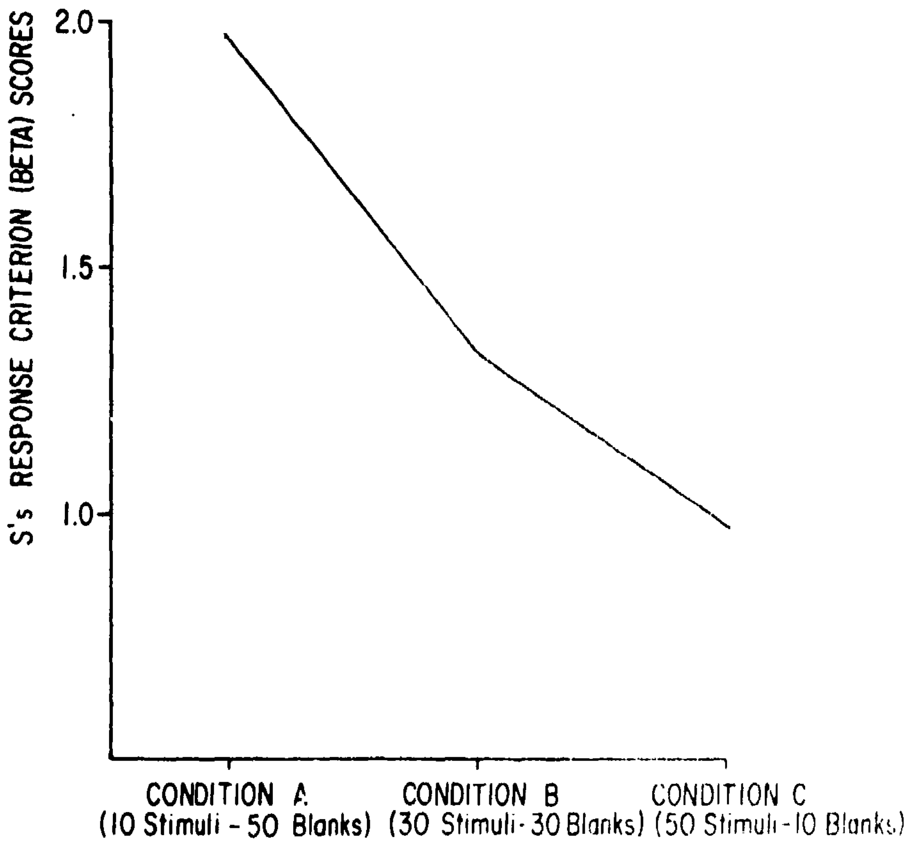

Figure 1

Relationship Among Response Criterion Measures Under Three Conditions of *a priori* Signal Probability

Table I

Analysis of Variance of Response Criterion Measures*

SOURCE	df	MS	F	p
Between Subjects				
Order	5	.185	.185	.561
Order X Subjects	36	.187		
Within Subjects				
Condition	2	.721	7.060	.002
Condition X Order	10	.145	1.416	.190
Condition X Order X Subjects	72	.102		

*The above ANOVA was calculated using the transformed criterion scores $\log_e$ (Beta + 1). See tect for explanation of transformed scores.

No significant differences were found between the sensitivity measures, d', for the three signal conditions (Table II). However, as presented in Table III, significant intercorrelations were found between the three d' measures obtained for each S under the three signal probability conditions. This may indicate some degree of stability of the sensitivity measure across conditions even with so few trials per condition.

Table II

Analysis of Variance of Sensitivity Measures*

SOURCE	df	MS	F	p
Between Subjects				
Order	5	1.706	1.838	.130
Order X Subjects	36	.928		
Within Subjects				
Condition	2	.492	1.501	.228
Condition X Order	10	.204	.621	.792
Condition X Order X Subjects	72	.328		

*The above ANOVA was calculated using the transformed sensitivity scores: $\log_e$ d'.

Table III

Intercorrelations of d' Under Three Signal Probability Conditions

	Condition A	Condition B	Condition C
Condition A (10ST-50 BL)	1.000	.578**	.483**
Condition B (30ST-30 BL)		1.000	.573**
Condition C (50ST-10 BL)			1.000

**$p < .01$

Correlations between the Beta and d' measures were also investigated as an indicant of the degree of orthogonality of the two derived scores. Theoretically, the shift in Beta in the present design were obtained under "isosensitivity" conditions; that is, S's d' should have been maintained fairly constant by employing the same "threshold" intensity throughout each of S's trials. However, as Table IV indicates, there was a relationship between Beta and d' in some of the conditions. A similar finding was reported by Ingham (30) between Beta and d' measures also obtained in an auditory detection task. Therefore, it appears that Beta and d' are not totally independent measures of response criterion and sensitivity, at least for some tasks and conditions and with the current methods of calculating the measures. Although this finding of a relationship between d' and Beta may have been due to the specific conditions employed by Ingham (30) and the present study, it does question the usual treatment of these scores as universally independent in other studies which are unable to test the orthogonality of the measures due to the small number of Ss usually employed in SDT research (e.g., 21, 65).

Table IV

Correlations Between Response Criterion Scores[a] and Sensitivity Scores (d')
Under Three Conditions of Signal Probability

	Condition A	Condition B	Condition C
Correlation r	.616**	.348*	-.127

[a]The transformed criterion scores, $\log_e$ (Beta + 1), were used in the above correlations.
*$p < .05$ **$p < .01$

Although the results of the S's response latencies will be treated more fully in later reports, some preliminary findings are available. Overall, there was a decrease in the latencies from the low signal frequency to the high signal frequency conditions for both correct hits and false positives. This basically mirrors the decreasing Beta values across conditions reported above, and is in close agreement with previously reported findings (15, 19). The determination of any relationship between the Beta scores and S's response latencies as well as a comparison of the latencies for the various types of responses will be treated in detail in future work.

CONCLUSION/IMPLICATIONS

As outlined in the Introduction, the primary concern of this preliminary research was the evaluation of the present design as a valid and viable experimental technique to establish an individual's criterion of response and to shift the response criterion in a theoretically predictable manner. Therefore, the major emphasis in this analysis was upon the change (if any) in each individual's criterion-Beta value from one condition of a priori signal probability to another. The initial findings of this study appeared to support the feasibility of determining a semi-automated, time-limited measure which reflects S's decisional processes within the statistical and conceptual framework of SDT. The response criterion measures obtained on the psychophysical task in the present design supported the theoretical use of SDT analysis of S's behavior, even though the task differed markedly in length from the usual designs employed in SDT research. Because of this basic difference, it was highly unlikely that many of the usual strict assumptions "required" within formal SDT were met. That the predicted shift in response criterion was obtained, however, indicated some degree of validity for the SDT analysis of data collected from relatively few trials.

Further work will examine individual differences among Ss in the extent to which they deviate from the predicted group trend across changing conditions of signal probability. A preliminary analysis of individual differences in response patterns indicates that extensive differences may be present. Figure 2 presents the Beta values for three Ss arbitrarily selected from the present research. Two of the three demonstrated decreasing Beta values over the signal probability conditions (as did the majority of Ss); however, of these two, S 4-H was consistently lower (i.e., less conservative) than S 17-C. Whether such an apparently reliable difference in individual criterion level among Ss on this task is reflected by meaningful differences in other settings will be investigated in future work. S 20-C, who was also consistently more conservative than S 4-H, did not demonstrate a decreasing response criterion across conditions. The meaning of this "rigid" conservativeness in some individuals will also be studied. Future investigations will attempt to determine whether these suggested individual differences in response conservativeness obtained in the detection setting

reflect a non-specific personality differentiation or "trait" which may underlie the variability of human behavior in many other areas. As part of this effort, these criterion or decisional differences will be investigated with regard to differences among student aviators on various psychological tests, psychomotor measures, and flight training performance.

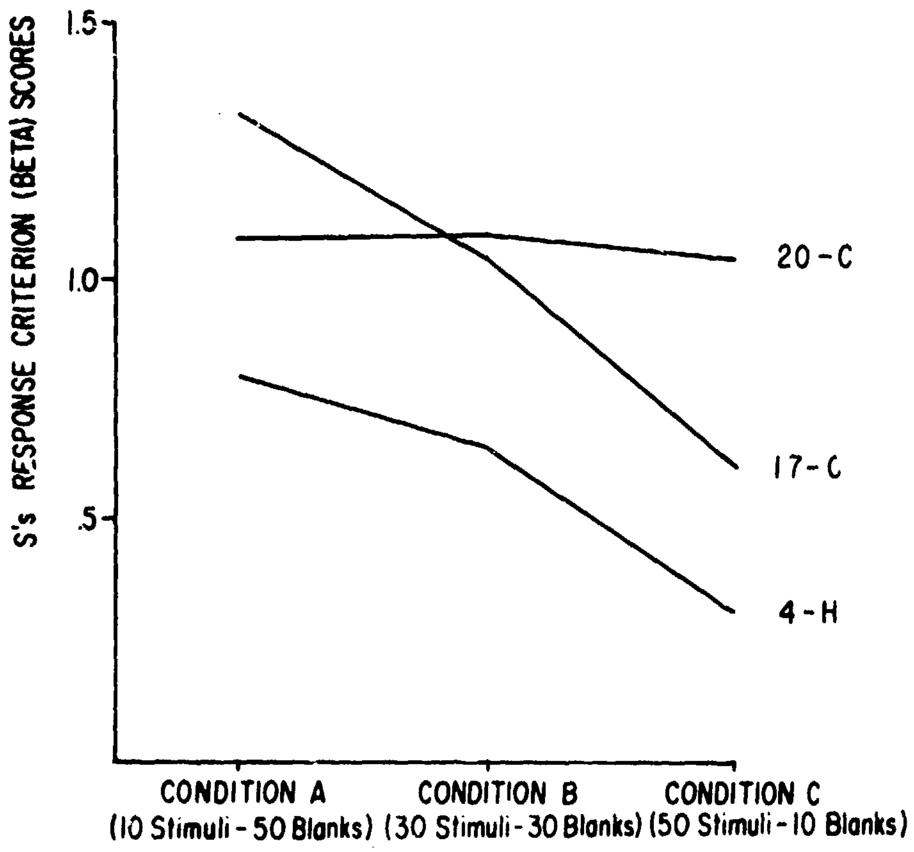

Figure 2

Response Criterion Measures for Selected Subjects Under Three Conditions of a priori Signal Probability

A partial replication of this preliminary study is currently in progress. The later study will also explore the possibility of certain changes in the basic design and examine other possible statistical measures of S's sensitivity and response criterion which might be applicable. Probable design changes include eliminating the central probability condition (30-30), while lengthening the number of trials for the two extreme conditions. This is expected to increase the reliability of the obtained measures by reducing S's response variance without increasing the overall test time required for each S. Other measures of S's sensitivity and response criterion reported in the current literature are being

examined to determine uncorrelated (i.e., orthogonal) measures of sensitivity and criterion. This would simplify the present problem of interpretation in those conditions where Beta and d' are not independent. Recently derived non-parametric measures of sensitivity and criterion within SDT which are akin to Beta and d' (22, 29, 51) also require investigation, since the computation of such scores makes different assumptions concerning the nature of S's behavior than do the parametric scores. These measures may prove more appropriate to the present design with its limited number of trials.

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APPENDIX A

Instructions Presented to Each S Prior to Condition A (10 stimulus-50 blank trials)

10 - 50 SECTION

In this section of the experiment, the warning light will come on a total of 60 times. However, the very faint tone which you are to detect over the noise background will be randomly presented on only 10 of these trials. In other words, the tone will be present in only one-sixth (1/6) of the total 60 trials. It is your task to detect on which trials the tone is present. Try to be as accurate as you can.

Throughout these 60 trials, please sit quietly in your chair and keep your eyes on the white warning light. Also keep your index finger on the button. The warning light and button are the same. When the warning light comes on, listen carefully for the tone. If you do hear the tone come on over the static background, press the white button in front of you until the light goes off. Remember that on the average the tone will be presented on approximately one out of every six trials.

To summarize, all you really have to do is simply press the button when you hear the tone over the static background. This tone will only be presented when the warning light is on. Furthermore, in the following 60 trials you are given the added information that the tone will be randomly presented in 10 of the 60 trials; that is, one about one out of every six trials.

Do you have any questions? If not, please put on your headsets and face forward.